ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Analysis of Wimax Physical Layer with Adaptive Modulation Techniques

Linus Antonio OforiAgyekum
B.E, ECE,
All Nations University College,
Koforidu, Eastern Region, Ghana.

TheophilusAnafo
BE,ECE,
All Nations University College,
Koforidu, Eastern Region, Ghana.

Abstract:

In this paper, we show the advancements in broadband and mobile communication has given many privileges to the subscribers for instance high speed data connectivity, voice and video applications in economical rates with good quality of services. The bit error rate performance of WIMAX has been carried out for different modulation techniques like BPSK, QPSK, QAM 16, and QAM 64. The performance evaluation of various aspects of the simulated model is obtained by plotting graphs between Bit Error Rate and Signal to Noise Ratio for different modulation techniques.

Orthogonal frequency division multiple access uses adaptive modulation technique on the physical layer of WiMAX and it uses the concept of cyclic prefix that adds additional bits at the transmitter end. The signal is transmitted through the channel and it is received at the receiver end. Then the receiver removes these additional bits in order to minimize the inter symbol interference, to improve the bit error rate and to reduce the power spectrum. In this paper, we investigated the physical layer performance on the basis of bit error rate, signal to noise ratio, power spectral density and error probability.

1. Introduction:

Before 1977, wireless communication was only used in military applications and for research purposes in satellite communication. The evolution of Advanced Mobile Phone System (AMPS) was the starting and turning point in wireless communication by offering a two way communication (i.e. Full Duplex Mode). It uses analogue technology and also supports data streams up to 19.2 Kbps [1][2]. The 4th Generation of mobile phone system is under research with an objective of fully Internet Protocol (IP) based integrated system [3].

The only difference with 3G is that it provides an IP based solution for data, voice and multimedia services to subscribers on the basis of two concepts i.e. "Anywhere" and "Anytime". The growing demand of multimedia services and the growth of Internet related contents lead to increasing interest to high speed communications.

The requirement for wide bandwidth and flexibility imposes the use of efficient transmission methods that would fit to the characteristics of wideband channels especially in wireless environment where the channel is very challenging. In this scenario, the users are always connected to the network with good and reliable data connectivity.

The generations that came after the 2.5th generation are also referred as the broadband generations because these generations have high data rates and provide multimedia services to their subscribers [4]. The term Broadband has no specific definition because every country has different characteristics of a broadband connection but normally broadband is defined as the high speed, reliable and on-demand internet connectivity.

Broadband access not only gives the access todownload files more quickly and provides faster web surfing but also enables multimedia applications like real-time audio, video streaming, multimedia conferencing and interactive gaming. The broadband connection is also used as voice telephony by using the Voice over Internet Protocol (VoIP) technology [3].

Different organizations such as International Telecommunication Union (ITU) or other international regulators specified that if the downloading speed is in the range of 256 Kbps to 2 Mbps or higher then it fall in the category of Broadband connections [6].

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

2. Simulation:

Here, we investigated the behavior of adaptive modulation technique of WiMAX. The adaptive modulation used following modulation techniques for modulating and demodulating the signal:

(1) Binary Phase Shift Keying (BPSK)

(2) Quadrature Phase Shift Keying (QPSK)

(3) 16Quadrature Amplitude Modulation (16-QAM)

(4) 64Quadrature Amplitude Modulation (64-QAM)

Based on these modulation techniques the following parameters were investigated.

(1) Bit Error Rate (BER)

(2) Signal to Noise Ratio (SNR)

(3) Power Spectral Density (PSD)

(4) Probability of Error (Pe)

The key points, in the simulations are:

(1) Microsoft Windows Vista Home Premium Edition.

(2) Matlab 7.8.0 (R2009a).

(3) Mersenne Twister - Random Number Generator (RNG) Algorithm.

(4) Noise is characterized as Gaussian.

(5) Fading is characterized as Rayleigh probability distribution function.

(6) Cyclic prefix is used.

(7) All the plotting is done to evaluate the performance on the basis of BER Vs SNR.

(8) Confidence intervals used for 32 times.

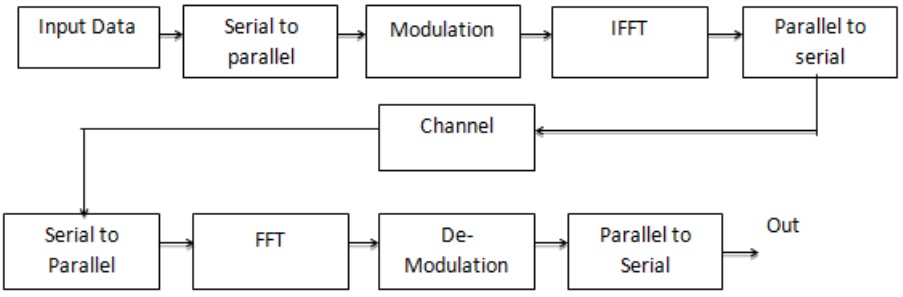


Figure (1): OFDM transmitter simple model.

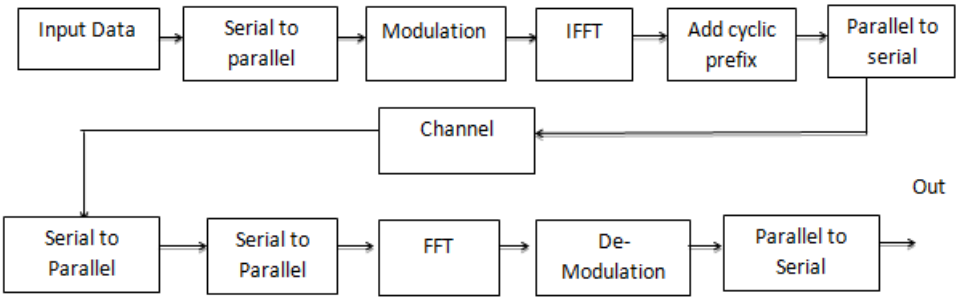


Fig 2: OFDM transmitter model with cyclic prefix.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

3. Simulation Results:

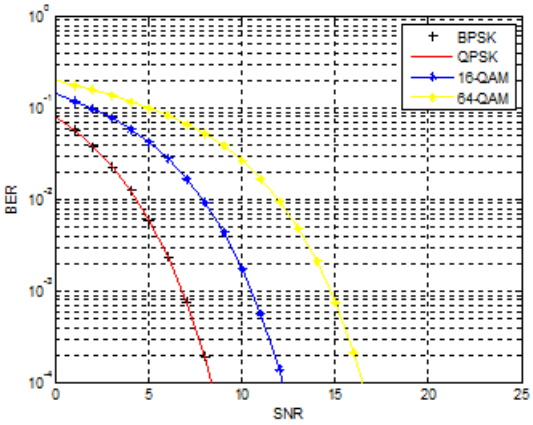


Figure 3: OFDM with Adaptive Modulation Techniques in PURE AWGN

In the above fig 3, we observe the pure AWGN channel condition using adaptive modulation techniques and compared the performance of these techniques while using the 256 multi carrier OFDM waves.

Modulation	SNR (%)				BW Utilization (%)			
	BPSK	QPSK	16-QAM	64-QAM	BPSK	QPSK	16-QAM	64-QAM
BPSK	-	0	157.14	200	-	200	400	600
QPSK	0	-	157.14	200	-	-	200	300
16-QAM	-	-	-	127.27	-	-	-	150
64-QAM	-	-	-	-	-	-	-	-

Table 1: Performance with respect to SNR and BW Utilization for pure AWGN Environment

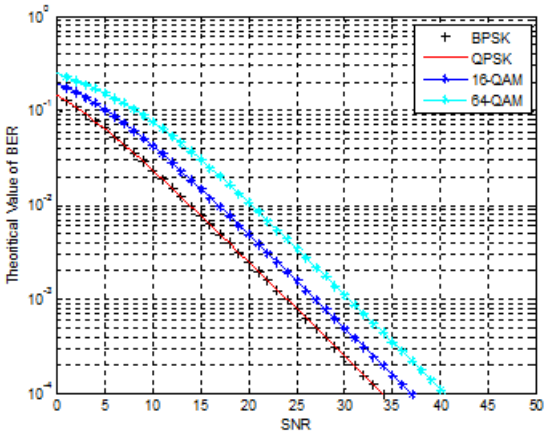


Fig 4: Theoretical Values of BER using Adaptive Modulation Techniques in OFDM

In Fig 4, shows the theoretical value of BER with respect to adaptive modulation techniques in the presence of pure AWGN is used to estimate the theoretical value of SNR with 256 sub carriers.

Modulation	SNR (%)				BW Utilization (%)			
	BPSK	QPSK	16-QAM	64-QAM	BPSK	QPSK	16-QAM	64-QAM
BPSK	-	0	112.5	125	-	200	400	600
QPSK	0	-	112.5	125	-	-	200	300
16-QAM	-	-	-	111.11	-	-	-	150
64-QAM	-	-	-	-	-	-	-	-

Table 2: Performance with respect to SNR and BW Utilization for theoretical value of BER.

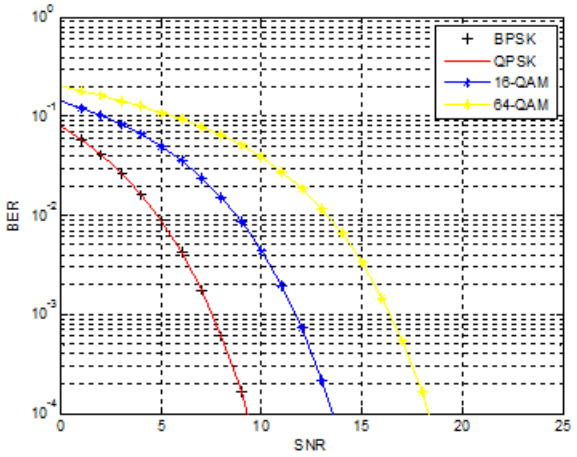
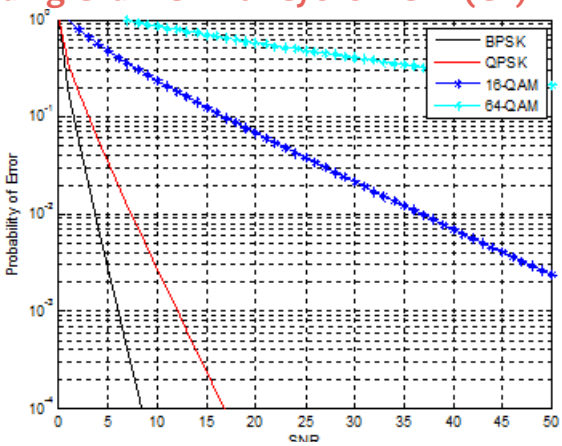


Fig 5: OFDM with Adaptive Modulation Techniques in AWGN + Rayleigh Fading Channel with Cyclic Prefix (CP).

Fig 5 shows the model which consists on AWGN and Rayleigh Fading Channel with the addition of Cyclic Prefix (CP) at the transmitter as well as receiver end. We investigate the effects of CP while using adaptive modulation techniques and compared the performance of OFDM symbols in terms of BER and SNR.

Modulation	SNR (%)				BW Utilization (%)			
	BPSK	QPSK	16-QAM	64-QAM	BPSK	QPSK	16-QAM	64-QAM
BPSK	-	0	160	226.66	-	200	400	600
QPSK	0	-	160	226.66	-	-	200	300
16-QAM	-	-	-	141.66	-	-	-	150
64-QAM	-	-	-	-	-	-	-	-

Table 3: Performance with respect to SNR and BW Utilization for OFDM in AWGN + Rayleigh Fading Channel with Cyclic Prefix (CP)



ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Fig 6: Probability of Error (Pe) for Adaptive Modulation.

Fig 6 shows the Probability of Error (Pe) in which the assumption rate of the error that introduce in the system because of noise and fading effects in the channel and also due to the cable losses at transmitter and the receiver ends.

Modulation	SNR (%)				BW Utilization (%)			
	BPSK	QPSK	16-QAM	64-QAM	BPSK	QPSK	16-QAM	64-QAM
BPSK	-	150	850	1850	-	200	400	600
QPSK	-	-	566.66	1233.33	-	-	200	300
16-QAM	-	-	-	217.61	-	-	-	150
64-QAM	-	-	-	-	-	-	-	-

Table 4: Performance with respect to SNR and BW Utilization for Probability of Error (Pe).

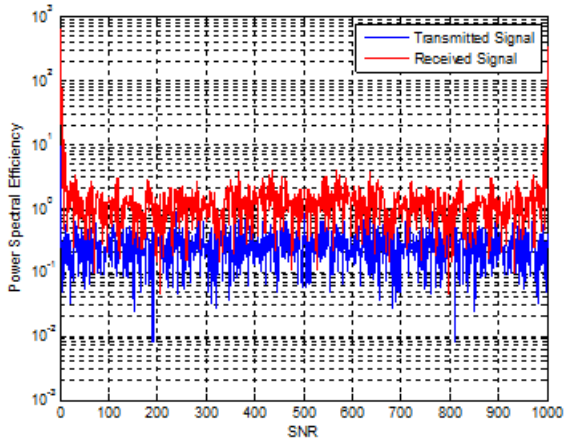


Fig 6: Effect of SNR level -100 on OFDM system with respect to Power Spectral Density

In fig 6, we observed that when we have SNR level equal to 100 dB then the difference of the input and output signals is very close in terms of power spectral density as compare to the difference when SNR equals to -100 dB.

4. Conclusion:

We concluded that BPSK is more power efficient and need less bandwidth amongst all other modulation techniques used in an OFDM adaptive modulation. In case of bandwidth utilization the 64QAM modulation requires higher bandwidth and gives an excellent data rates as compared to others. While the QPSK and the 16QAM techniques are in the middle of these two and need higher bandwidth and less power efficient than BPSK.

But they required lesser bandwidth and lower data rates than 64QAM. Also, BPSK has the lowest BER while the 64-QAM has highest BER than others.

5. References:

1)Kioskia.net, Mobile Telephony,Nov.8, 2008.

2)Richard C. Dorf, The Engineering Handbook, 2nd ed., Illustrated and Published by CRC Press

3)William Stalling, "Wireless Communications & Networks", 2nd ed., Prentice Hall, 2005.

4)Theodore S. Rappaport, "Wireless Communications: Principles & Practice", 2nded., Prentice Hall, 2001.

5)Simon Haykin, "Digital Communications", Wiley, John & Sons, Incorporated, 1998, ISBN- 13: 9780471629474.

6)Jeffrey G. Andrews, Arunabha Ghosh, Rias Muhamed, "Fundamentals of WiMAX: Understanding Broadband Wireless Networking", Prentice Hall, 2007.

7)Eric Lawrey, "The suitability of OFDM as a modulation technique for wireless telecommunications, with a CDMA comparison", Dissertation submitted at James Cook University, 1997.

8)Intel White Paper, Wi-Fi and WiMAX Solutions: "Understanding Wi-Fi and WiMAX as Metro-Access Solutions," Intel Corporation, 2004.

9)J. G. Andrews, Ph. D and R. Muhamed, Fundamentals of WiMAX : Understanding BroadBand Wireless Networking. Upper Saddle River, NJ: Prentice Hall, 2007.

10)IEEE 802.16-2004, "IEEE standard for local and metropolitan area networks – part 16: Air interface for fixed broadBand wireless access systems," IEEE, 2004.